

**Federal State Autonomous Educational Institution of Higher Education "Moscow
Institute of Physics and Technology
(National Research University)"**

APPROVED
**Head of the Phystech School of
Biological and Medical Physics**
D.V. Kuzmin

Work program of the course (training module)

course: Physico-chemical Biology of Proteins: from Structure to Function and Biomedical Application/Физико-химическая биология белков: от структуры к функции и биомедицинскому применению

major: Biotechnology

specialization: Medical Biotechnology/Медицинская биотехнология
Phystech School of Biological and Medical Physics
Center for educational programs in bioinformatics

term: 1

qualification: Master

Semester, form of interim assessment: 2 (spring) - Exam

Academic hours: 30 АН in total, including:

lectures: 0 АН.

seminars: 30 АН.

laboratory practical: 0 АН.

Independent work: 75 АН.

Exam preparation: 30 АН.

In total: 135 АН, credits in total: 3

Authors of the program:

O.Y. Belogurova-Ovchinnikova, phd (candidate of biological sciences)

A.A. Emelyanova, candidate of chemical sciences

The program was discussed at the Center for educational programs in bioinformatics 04.06.2020

Annotation

The purpose of this discipline is to provide students with the most important ideas about the fundamental foundations of physical and chemical biology and modern research methods used in the study of the components of living matter. After completing the course, the student will understand the main components of proteins and peptides, the main functions of proteins and peptides.

1. Study objective

Purpose of the course

to give students the most important ideas about the fundamental foundations of physical and chemical biology and about modern research methods used in this area to study the components of living matter.

Tasks of the course

formation of basic knowledge about the relationships between the structure and function of proteins, peptides, nucleic acids, carbohydrates, lipids and other biologically active compounds;

practical mastering by students of methods for studying the components of a living cell on the basis of a program of laboratory special workshops on the most important sections of physical and chemical biology;

formation of basic experimental skills among students and their acquisition of practical experience necessary for conducting independent research in the field of physical and chemical biology.

2. List of the planned results of the course (training module), correlated with the planned results of the mastering the educational program

Mastering the discipline is aimed at the formation of the following competencies:

Code and the name of the competence	Competency indicators
UC-1 Use a systematic approach to critically analyze a problem and develop an action plan	UC-1.1 Systematically analyze the problem situation, identify its components and the relations between them
	UC-1.2 Search for solutions by using available sources
	UC-1.3 Develop a step-by-step strategy for achieving a goal, foresee the result of each step, evaluate the overall impact on the planned activity and its participants
Gen.Pro.C-1 Gain fundamental scientific knowledge in the field of biological, physical, mathematical sciences	Gen.Pro.C-1.1 Apply fundamental scientific knowledge in the field of biological, physical, mathematical sciences
	Gen.Pro.C-1.2 Consolidate and critically assess professional experience and research findings
	Gen.Pro.C-1.3 Understand interdisciplinary relations in applied biological, physical, mathematical sciences and apply them in professional tasks
	Gen.Pro.C-1.4 Able to plan, organise and carry out research work in biotechnology, correctly process the results of experiments and draw valid opinions and conclusions
Gen.Pro.C-5 Undertake professional training, achieve professional growth, and become a team leader in a professional sphere, tolerant of social, ethnic, religious, and cultural differences	Gen.Pro.C-5.1 Tolerate social, ethnic, religious, and cultural differences in teamwork
	Gen.Pro.C-5.2 Manage a small professional team
	Gen.Pro.C-5.3 Apply new knowledge and achieve personal and professional growth

3. List of the planned results of the course (training module)

As a result of studying the course the student should:

know:

- how to describe different levels of protein structure;
- how to describe the relationship between protein structure and function;
- the significance of domains in protein function;
- the basics of protein synthesis, folding, sorting and degradation;
- the importance of post-translational modifications;
- the basics of protein analysis techniques;
- the biological role of proteins;
- the examples of biomedical application of proteins.

be able to:

- analyse and interpret protein sequences and structures and use this information to predict protein function;
- describe how proteins can be used for production and development of drugs, for biotechnological and other industrial and scientific purposes, and explain how this is facilitated by knowledge of the structure and function of proteins;
- choose the necessary methods and equipment for protein research;
- analyse scientific literature;
- present literature data in a clear and well-organised manner.

master:

- skills of assimilation of a large amount of information.

4. Content of the course (training module), structured by topics (sections), indicating the number of allocated academic hours and types of training sessions

4.1. The sections of the course (training module) and the complexity of the types of training sessions

№	Topic (section) of the course	Types of training sessions, including independent work			
		Lectures	Seminars	Laboratory practical	Independent work
1	Structure of amino acids and primary structure of proteins		3		7
2	Spatial structure of globular proteins as the basis of their functional diversity		3		7
3	Domain organization of proteins		3		7
4	Main structural features of fibrillar proteins		3		7
5	The general scheme of protein biosynthesis		3		7
6	The role of signal peptides in protein sorting		3		8
7	The role of chaperones and chaperonins		3		8
8	Post-translational modification of proteins		3		8
9	Protein degradation		3		8
10	The subject of biotechnology		3		8
AH in total			30		75
Exam preparation		30 AH.			
Total complexity		135 AH., credits in total 3			

4.2. Content of the course (training module), structured by topics (sections)

Semester: 2 (Spring)

1. Structure of amino acids and primary structure of proteins

The main properties of amino acids. The main stages in the development of knowledge about the structure and functions of peptides and proteins. The biological role of proteins. Configuration of the peptide bond. Ramachandran plot.

2. Spatial structure of globular proteins as the basis of their functional diversity

The concept of structural motifs of globular proteins: calcium-binding motif (EF-arm), β -hairpin, Greek key, β - α - β -motif, etc.

3. Domain organization of proteins

Domain organization of proteins; classes of domain structures: α -helical domains, β -structural domains, α / β -domains, α + β -domains. Representatives of characteristic domain classes and their functions.

4. Main structural features of fibrillar proteins

The structure of α -keratin, β -silk fibroin, collagen. extracellular matrix proteins. The structure of muscle fibrils, actin-myosin complex. The structure of amyloid fibrils. Prion diseases. Alzheimer's disease and amyloid beta fibrils.

5. The general scheme of protein biosynthesis

Structure and functional sites of mRNA. Primary, secondary, tertiary structures of RNA, the role of modified nucleotides. tRNA. Aminoacylation of tRNA, aminoacyl-tRNA synthetases, their structure and mechanism of action. Prokaryotic and eukaryotic types of ribosomes. Three stages of translation: initiation, elongation and termination.

6. The role of signal peptides in protein sorting

Import of proteins into cellular organelles: nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus, peroxisomes, chloroplasts.

7. The role of chaperones and chaperonins

The role of chaperones and chaperonins. Hsp70 Chaperones. Structure of the GroEL / GroES system

8. Post-translational modification of proteins

Post-translational modification of proteins

9. Protein degradation

Lysosomal and proteasome pathways of protein degradation in the cell. Multi-catalytic proteinase complexes. The structure of 26S proteasome. Ubiquitin and its role in proteolytic degradation. Ubiquitin-like proteins. Non-canon signals of proteasome degradation. Drugs based on proteasome inhibitors

10. The subject of biotechnology

Introduction to biotechnology and biomedicine. The main areas of biotechnology. Introduction to protein engineering. Biomedical application of recombinant proteins. Rational design and redesign of protein molecules. Recombinant hormones and enzymes. The principles of creating artificial proteins with desired properties. Market trends in recombinant protein therapeutics use.

5. Description of the material and technical facilities that are necessary for the implementation of the educational process of the course (training module)

Equipment required for lectures and practical exercises: auditorium, computer and multimedia equipment (projector, sound system).

6. List of the main and additional literature, that is necessary for the course (training module) mastering

Main literature

Literature is provided at the base department

1. Proteins: Biochemistry and Biotechnology / Gary Walsh, – 2ed.
2. Protein Structure and Function / Gregory A. Petsko and Dagmar Ringe.
3. Molecular Biology of the Gene / James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, – 7 ed.
4. Introduction to Protein Structure / Carl Branden and John Tooze, – 2ed.

Additional literature

7. List of web resources that are necessary for the course (training module) mastering

Not used

8. List of information technologies used for implementation of the educational process, including a list of software and information reference systems (if necessary)

For some of the lessons, you will need Zoom. Google Drive to access course materials. The presence of smartphones / laptops during classes is encouraged to participate in interactive exercises.

9. Guidelines for students to master the course

A student who studies discipline must, on the one hand, master a general conceptual apparatus, and on the other hand, must learn to apply theoretical knowledge in practice.

As a result of studying the discipline, the student should know the basic definitions of the discipline, be able to apply this knowledge to solve various problems.

Successful learning requires:

- visits to all classes provided by the curriculum for the discipline;
- conducting the abstract of occupations;
- intense independent work of the student.

Independent work includes:

- reading recommended literature;
- study of educational material, preparation of answers to questions intended for self-study;
- solving problems offered to students in the classroom;
- preparation for performance of tasks of the current and intermediate certification.

An indicator of possession of the material is the ability to answer questions on discipline topics without an outline.

It is important to achieve an understanding of the material being studied, and not its mechanical memorization. If it is difficult to study individual topics, questions, you should seek advice from the teacher.

Intermediate control of students' knowledge in the form of problem solving in accordance with the subject of classes is possible.

Assessment funds for course (training module)

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Authors:

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1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
UC-1 Use a systematic approach to critically analyze a problem and develop an action plan	UC-1.1 Systematically analyze the problem situation, identify its components and the relations between them
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Gen.Pro.C-5 Undertake professional training, achieve professional growth, and become a team leader in a professional sphere, tolerant of social, ethnic, religious, and cultural differences	Gen.Pro.C-5.1 Tolerate social, ethnic, religious, and cultural differences in teamwork
	Gen.Pro.C-5.2 Manage a small professional team
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2. Competency assessment indicators

As a result of studying the course the student should:

know:

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be able to:

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- describe how proteins can be used for production and development of drugs, for biotechnological and other industrial and scientific purposes, and explain how this is facilitated by knowledge of the structure and function of proteins;
- choose the necessary methods and equipment for protein research;
- analyse scientific literature;
- present literature data in a clear and well-organised manner.

master:

- skills of assimilation of a large amount of information.

3. List of typical control tasks used to evaluate knowledge and skills

During the current control, the student should be able to answer the following questions:

The main properties of amino acids.

The biological role of proteins.

The concept of structural motifs of globular proteins: calcium-binding motif (EF-arm), β -hairpin, Greek key, β - α - β -motif, etc.

Prion diseases. Alzheimer's disease and amyloid beta fibrils.

Primary, secondary, tertiary structures of RNA, the role of modified nucleotides.

Prokaryotic and eukaryotic types of ribosomes.

Three stages of translation: initiation, elongation and termination.

Drugs based on proteasome inhibitors.

The principles of creating artificial proteins with desired properties.

During the class, interactive discussions can take place in the course chats, which will be homework. It is possible to perform patent search as an independent task. Successful completion of all tasks in the course and the implementation of control slices of knowledge gives an advantage on exam.

4. Evaluation criteria

The main properties of amino acids.

The biological role of proteins.

The concept of structural motifs of globular proteins: calcium-binding motif (EF-arm), β -hairpin, Greek key, β - α - β -motif, etc.

Prion diseases. Alzheimer's disease and amyloid beta fibrils.

Primary, secondary, tertiary structures of RNA, the role of modified nucleotides.

Prokaryotic and eukaryotic types of ribosomes.

Three stages of translation: initiation, elongation and termination.

Drugs based on proteasome inhibitors.

The principles of creating artificial proteins with desired properties.

The mark is excellent (10 points) - it is given to a student who has shown comprehensive, systematic, deep knowledge of the curriculum of the discipline, who has an interest in this subject area, has demonstrated the ability to confidently and creatively put them into practice in solving specific problems, and a free and proper substantiation of decisions.

The mark is excellent (9 points) - it is given to a student who has shown comprehensive, systematic, in-depth knowledge of the curriculum of the discipline and the ability to confidently put them into practice in solving specific problems, free and proper substantiation of the decisions made.

The mark is excellent (8 points) - given to a student who has shown comprehensive, systematic, in-depth knowledge of the curriculum of the discipline and the ability to confidently apply them in practice in solving specific problems, correct justification of decisions made, with some shortcomings.

A mark is good (7 points) - it is put up for a student, if he knows the material firmly, sets it up competently and in essence, knows how to apply the knowledge gained in practice, but does not competently substantiate the results obtained.

Evaluation is good (6 points) - it is put up to a student, if he knows the material firmly, sets it up correctly and in essence, knows how to apply this knowledge in practice, but admits some inaccuracies in the answer or in solving problems.

A mark is good (5 points) - it is given to a student, if he basically knows the material, correctly and essentially sets it out, knows how to apply this knowledge in practice, but allows a sufficiently large number of inaccuracies to answer or solve problems.

Grade satisfactorily (4 points) is given to a student who has shown the fragmented, fragmented nature of knowledge, insufficiently correct formulations of basic concepts, violations of the logical sequence in the presentation of program material, but at the same time he has mastered the main sections of the curriculum necessary for further education and can apply knowledge is modeled in a standard situation.

Grade satisfactorily (3 points) - given to a student who showed the fragmented, scattered nature of knowledge, making mistakes in formulating basic concepts, disrupting the logical sequence in presenting program material, poorly masters the main sections of the curriculum required for further education and even applies the knowledge gained in a standard situation.

The rating is unsatisfactory (2 points) - is given to a student who does not know most of the main content of the curriculum of the discipline, makes gross mistakes in the wording of the basic principles and does not know how to use this knowledge when solving typical tasks.

Unsatisfactory mark (1 point) - is given to a student who does not know the main content of the discipline's curriculum, makes gross errors in the wording of the basic concepts of the discipline and does not have any skills to solve typical practical problems.

5. Methodological materials defining the procedures for the assessment of knowledge, skills, abilities and/or experience

During the oral exam, the student is given 30 minutes to prepare. The interview for a student in an oral exam must not exceed one astronomical hour.